WINTERING BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) AND
HUMAN RECREATIONAL USE OF
THE SOUTH SHORE OF THE LAKE TAHOE BASIN

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INTRODUCTION

Historical Status and Biology of Bald Eagles

The federally threatened bald eagle is the only species of the fish or sea eagle family found in North America and is endemic to North America (USDI, 1986). Eagles formerly bred throughout the continent, but now primarily nest in Alaska, Canada, the Pacific Northwest states, the Great Lakes states, Florida, and Chesapeake Bay (USDI, 1986). Reproduction in most remaining bald eagle populations drastically declined in the mid 1900's as a result of organochlorine pesticides which cause excessive eggshell thinning. Habitat destruction continues to be the most significant threat to bald eagles. Recreational and urban land development, logging, and other human disturbance are adversely affecting the suitability of breeding, wintering, and foraging areas (USDI, 1986). Although many individual and smaller scale actions may not jeopardize species recovery, cumulative long-term effects throughout the species range pose the single most important threat to recovery (USDI, 1986).

Currently in California, occupied territories of breeding bald eagles are located in 28 counties and approximately 26% occur in Shasta County (CDF&G 1999). Nearly half of California's wintering population occurs in the Klamath Basin and all the wintering population occurs at large lakes and man-made reservoirs. Detrich (1986) summarized several banding and radio-telemetry studies of bald eagles and found that many bald eagles that winter in California are from the Canadian breeding population and other parts of the western United States. Detrich (1986) concluded that the maintenance of quality wintering habitat in California may be important for the species breeding population as the condition of raptors returning from wintering grounds is important for their reproductive success.

Records of the historical presence of bald eagles in the Tahoe Basin span several hundred years. Bald eagles were reported to nest at an unidentified location near Lake Tahoe in 1874 and 1875, and near the present site of Homewood, CA in 1877 (Orr and Moffitt, 1971). Golightly et al. (1991) found no mention of bald eagles having been observed by ornithologists visiting the Tahoe Basin between 1901 and 1934 in his review of published field notes. However, McLean (1935 as cited in Detrich 1986) suggested that at least one pair of eagles nested in the area of Lake Tahoe in 1935. California Department of Fish and Game records indicate nest activity at

Emerald Bay on Lake Tahoe in 1967, 1970, and 1971 (Detrich, 1986). Reed (1979) reported that a nest at Eagle Point in Emerald Bay was used successfully in 1970, but was abandoned in 1971. However, no definitive nesting activity was documented. In 1996, a nest attempt at Marlette Lake, NV failed after a pair produced eggs (LTBMU unpublished data). A pair of eagles successfully fledged at least one eaglet in 1997 and two eaglets in 1998 from a nest on the California side of Lake Tahoe (LTBMU unpublished data). No evidence of nesting was documented in the Basin in 1999.

Wintering bald eagles in the Tahoe Basin were reported as "occurring more often in fall and winter" than in the summer by Orr and Moffit (1971). From 1970 through 1990, bald eagles were observed perching and hunting at Emerald Bay and D.L. Bliss State Parks (CA State Parks unpublished data). In recent years Forest Service personnel have observed 10-20 bald eagles perching and hunting along the south shore of Lake Tahoe (Figure 1).

Perch Sites

Bald eagle perch site selection has been studied extensively throughout the United States (Edwards, 1969; Lish, 1973; Shea, 1973; Servheen, 1975; Stalmaster and Newman, 1979; Steenhof et al., 1980; Fielder and Starkey, 1986; Chester et al., 1990; Chandler et al., 1995). Bald eagle use of perches varies based on perch site availability near water. Researchers have documented bald eagles perching in ponderosa pine (*Pinus ponderosa*), cottonwood (*Populus* spp.), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*) boxelder (*Acer negundo*), American elm (*Ulmus americana*), green ash (*Frazinus pennsylvancia*), peach-leaved willow (*Salix amygdaloides*), and hackberry (*Celtis occidentalis*) (Fielder and Starkey, 1986; Steenhof et al., 1980; Stalmaster and Newman, 1979). Reed (1979) identified eight individual perch sites favored by bald eagles in the Taylor Creek Marsh area. Two species, lodgepole (*Pinus contorta* var. *murrayana*) and Jeffrey pine (*Pinus jeffreyii*) were used and all the trees were dominant or predominant in the surrounding stands. Several large aspen (*Populus tremulides*) and cottonwood were used along the banks of Taylor Creek in the fall and winter after their leaves had dropped.

Although the species of tree used by bald eagles for perching varies considerably by geographic region, tree characteristics are similar throughout the species' range. Bald eagle perch trees have the following characteristics: bordered by open areas, stout horizontal branches; tall; large diameter; close proximity to water; close proximity to feeding areas; and provide a good view of surrounding area (Servheen, 1975; Stalmaster and Newman, 1979; Fielder and Starkey, 1986). Reed (1979) described trees used by wintering bald eagles in the Tahoe Basin as exhibiting open branching and either dead standing, dead topped, or having some dead lateral branches in a live crown. Heights of the favored perch trees ranged from 24 to 31 m and were at least 12 m taller than the understory of the surrounding stand.

Bald eagles may use artificial perches when natural perches are lacking (USDI, 1986). Eagles used man-made perch sites in eastern Washington along the Columbia River (Fielder and Starkey, 1986). However, eagles did not use artificial perches in South Dakota (Steenhof et al., 1980) and eagles have not been observed to use artificial perches constructed for Osprey use in the Taylor Creek Marsh area of the Tahoe Basin (LTBMU unpublished data).

Diet

Bald eagle food habits have been well studied and vary greatly by region, season, and habitat (Dunstan et al., 1975; Sherrod et al., 1976; Stalmaster et al., 1979; McEwan and Hirth, 1980; Todd et al., 1982; Altman, 1983; Barber et al., 1983; Knight and Knight, 1983; Cash et al., 1985; Knight and Knight, 1986; Bayer, 1987; Isaacs and Anthony, 1987; Keister et al., 1987; Craig et al., 1988; Knight and Skagen, 1988; Frenzel and Anthony, 1989; Skagen et al., 1991; Watson et al., 1991; Stalmaster and Plettner, 1992; Grubb, 1995). The Pacific Bald Eagle Recovery Plan (USDI, 1986) identified adequate food supply as the most critical component of eagle wintering habitat. Within the Pacific Recovery area fish, waterfowl, jack rabbits, and carrion comprise the most common food sources. Local and seasonal variation in the diet of bald eagles and diet closely follows food availability. Many species are consumed by bald eagles including anadromous and non-anadromous fish, waterfowl and gulls, mammals (dead and alive, small and large), reptiles, and invertebrates (USDI, 1986).

Food availability and foraging behavior associations have been made by some researchers. For example, Skagen et al. (1991) showed that bald eagles were more tolerant to human activity when they were stressed by low food availability. Stalmaster (1983) suggested that feeding in social groups increased bald eagle efficiency in locating and exploiting food sources. Disturbance to feeding bald eagles could alter social interactions by decreasing efficiency of energy acquisition. Skagen et al. (1991) found that eagles fed more at a site on days of no disturbance than days when feeding was disrupted and after eagles were disturbed, they seldom returned to feed that day.

Fish are one of the most important components to the diet of bald eagles (USDI, 1986). Reed (1979) suggested that Kokanee salmon (*Oncorhynchus nerka*) carcasses provide essentially all the eagles' nutritional needs and other food sources go virtually unnoticed by eagles during October and November in the Lake Tahoe Basin. Although it is native to the Pacific Northwest, kokanee are not native to Lake Tahoe or California (Curtis and Fraser, 1948; Fraser and Pollitt, 1951). In 1944, kokanee were accidentally introduced to Lake Tahoe when they escaped from the Tahoe Hatchery. Some of the escaped fish returned to the hatchery outflow in 1946 and a sport-fishery introduction program began in 1949 (Fraser and Pollitt, 1951). Today Lake Tahoe's fishery consists almost entirely of introduced species (Elliott-Fisk et al., 1997). As a result of road construction, channelization, and devegetation, only a few spawning streams, including Taylor Creek, are suitable for kokanee spawning (J. Reiner, pers. comm.). The number of spawning kokanee salmon in Taylor Creek varies with the structural condition of the creek, but average between 20,000 and 40,000 (~ 13,000 to 27,000 kg of food) each year (J. Reiner, pers. comm.). Kokanee spawning in Taylor Creek begins as early as September but can occur as late as November (J. Reiner, pers. comm.) and is dependant upon the genetic background of the fish and in part by lake and stream temperatures (Moyle, 1976). Salmon carcasses can persist frozen in Taylor Creek after spawning for the remainder of winter months and provide a source of nutrients for many species.

Recreational Land Use of Bald Eagle Habitat

Human recreation resulting in disruption of wildlife's ecology is an emerging issue in natural resources management (reviews in Knight and Gutzwiller, 1995; Knight and Skagen, 1988). Boyle and Samson (1983) listed 189 literature references that identified effects of non-consumptive outdoor recreation on terrestrial vertebrates in North America. More than 81% (136) of these articles reported negative effects on wildlife while less than 7% (11) reported positive effects and 22% (41) reported no or undetermined effects.

Evaluations of the effects of recreational human disturbance on nesting bald eagles are common (Mathisen, 1968; Anthony and Isaacs, 1989; Grubb and King, 1991; Buehler et al., 1991a; Grubb et al., 1992; Steidl and Anthony, 1996). Several studies have examined the relationship between recreation and wintering bald eagle activity (Shea, 1973; Servheen, 1975; Stalmaster and Newman, 1978; Russel, 1980; Skagen, 1980; Steenhof et al., 1980; Walter and Garrett, 1981; Knight, 1984; Stalmaster and Kaiser, 1998). Negative impacts of recreational activities on bald eagles include: reduced fitness, altered behavior, death, changes in demographics, distribution (spatially and temporally), and community composition and interactions.

The effects of recreational activities on bald eagles are variable and depend on the context in which the activity and eagle encounters take place, the eagles behavioral and physical state, and the spatial and temporal variation of the interaction (Grubb and King, 1991; Anthony et al., 1995). McGarigal et al. (1991) described two forms of disturbance which result from human-eagle interactions. The first form, active displacement, involves humans actively approaching or passing by eagles. The second form, passive displacement, involves human activities that influence an eagle's environment and cause eagles to change their location and behavior.

McGarigal et al. (1991) described active displacement as humans coming into contact with eagles by boating past eagles on a narrow section of river. This terminology could also apply to open lakes and marshes when humans may have access to areas by foot where eagles congregate. Several researchers have examined active displacement by measuring the distance between a human activity and an eagle at which an eagle flushes. This method enables

researchers to establish a flush response (percentage of human-eagle interactions within a specified distance which result in an eagle flushing) or a mean flush distance. McGarigal et al. (1991) found that <6% of human activities within 500 m of breeding eagles resulted in flushing disturbance on the Columbia River in Washington. Skagen (1980) found that 42.5% of wintering eagles on the Skagit River in Washington flushed when boats, pedestrians, or vehicles approached within 500 m. Fraser et al. (1985) found that breeding bald eagles in Minnesota flushed at 57-991 m ($\bar{x}$ = 476 m) at the approach of a pedestrian. Seventy-five percent of all flight responses occurred when eagles in Michigan were within 200 m of vehicles, pedestrians, boats, or aircraft (Grubb et al., 1992). Steidl and Anthony (1996) reported that 52% of all non-breeding summer eagles in Alaska that flushed in response to rafts on the Gulkana River did so between 25 and 100 m. In northwestern Washington, researchers reported that flushing distances of perched and feeding bald eagles averaged 133 and 224 m in response to boating and pedestrian activities on the Skagit River Bald Eagle Natural Area (Stalmaster and Kaiser, 1998). Finally, Russel (1980) found that 59% of all wintering eagles along three rivers in northwestern Washington flushed in response to a census raft and 100% of eagles in feeding activities were flushed.

The second form of displacement described by McGarigal et al. (1991) is passive displacement. Human activities affect the eagle's environment and cause changes in the eagle's distribution or behavior (Anthony et al., 1995). McGarigal et al. (1991) reported that breeding eagles avoided an area within 400 m (range 200-900 m) of an experimental stationary boat. Eagles also spent less time and made fewer foraging attempts in the experimental area during the experimental period. Knight et al. (1991) found that eagles were more likely to be on the ground than in perches when anglers were absent from riverbanks. Eagles on their study area were constrained to feed on the ground, as the salmon carcasses they fed on were too heavy to take to perch trees. This led Knight et al. (1991) to suggest that human activity disrupted feeding, and reduced energy intake and increased energy expenditure. Skagen et al. (1991) reported that after a disturbance, eagles seldom returned to feed that day. On the Skagit River in Washington, Skagen (1980) found a significant decrease in the proportion of eagles feeding when human activity was present within 200 m of the feeding area in the previous 30 minutes. Stalmaster and

Newman (1978) found that disturbance in areas of high human activity at major feeding grounds caused a shift in distribution which resulted in displacement of birds to lower quality habitat and confined the population to a smaller area. Eagles utilizing a portion of the Sauk and Suiattle Rivers in Washington having lower human activity showed significantly higher sensitivity to human disturbance than areas with higher levels of activity (Russel, 1980).

Forest Service surveys have documented Taylor Creek as the major area of use for the wintering population of bald Eagles on the LTBMU. These surveys have also documented disturbance to foraging eagles throughout the basin (Reed 1979). Disturbance to eagles is primarily human caused, including hikers, cross country skiers, and pets. Past studies have also documented eagle occurrence along the shoreline. Bald eagles have been observed perching at many locations, including within the public land designated as recreational areas.

The present study describes bald eagle and human activities and tests hypotheses about their interactions on the South shore of Lake Tahoe California. Our specific objectives were to:

1) Document the location and activities of foraging bald eagles in study area.
2) Describe and map perch locations of bald eagles in study area.
3) Quantify human/eagle interactions.

STUDY AREA

The study was conducted on the South shore of Lake Tahoe (Figure 2) in El Dorado County, California, from November 1996 to March 1997 and October 1997 to March 1998. Elevation in the study area was approximately 1900 m. Principal forest types include Jeffrey (*Pinus jeffreyi*) and lodgepole (*P. contorta*) pine. The study area is in the Fallen Leaf Management Area of LTBMU, and contains the most intensively used, developed recreation areas on National Forest System lands in the basin. The area includes Pope, Baldwin, and Kiva beaches; Camp Richardson Resort; Camp Richardson Corral; LTBMU Visitor Center; Fallen Leaf Campground; two organization camps; Tahoe Tallac Association facilities; and several summer home tracts (USDA 1988).

METHODS

Eagle and Human Activities

Data on bald eagle avoidance behavior and use of the study area were collected during the wintering activity period (October 1, 1997 - March 31, 1998). The study area was divided into 14 observation units from which bald eagle and human activities were observed (Figure 2.) Units were chosen based on their proximity to areas which would receive increased use under proposed recreational activity expansion, historical bald eagle use, and ability to completely observe the study unit. With the exception of Taylor Creek and the southshore shoreline, observations occurred from a fixed point. Taylor Creek is over one mile long and bordered by thick vegetation and therefore our protocol for this area included walking along the creek to search for eagles. The southshore shoreline was surveyed from a boat and was divided into 4 units to allow for complete viewing of a unit.

The time of day which observations occurred was stratified to document human and eagle use during daylight hours and later grouped into early (06:00 to 09:59), mid (10:00 to 13:59) and late (14:00 to 18:00) time periods. Eagle and human use observations were conducted throughout the week to monitor and record human/eagle interactions during weekend and weekday visitor use. Surveys of each observation unit were conducted for one hour (n = 449). If an eagle was still in view at the end of the one hour period, we continued to monitor the eagle(s) to collect behavioral and activity data. These post-one hour observations were not included in eagle disturbance analyses. Eagle presence and behavior was observed from maximum possible distances with binoculars and spotting scopes to minimize disturbance by the observer. Eagle activities (perching, feeding/foraging, flying, etc.) and their reactions to disturbance (none, alerted/restless, flight, etc.) were recorded during one hour observations. Human activities (hiking, boating, skiing, etc.) were also recorded. Distances from eagle to human activity and flight distances were estimated using topographic maps and Universal Transverse Mercator (UTM) grid readers. We plotted eagle locations in the field on 7.5 minute U.S. Geological Survey Maps to determine UTM coordinates.

Perch Sites

In the winter of 1997/98, we identified all perch locations and selected those locations used on at least two different observation occasions for analyses. We then measured attributes at these perch sites that included: perch tree dbh (cm), tree height (m), tree condition (live vs dead), and tree top condition (live vs dead). For perch trees that were used ≥ 3 occasions, we also measured stand features such as tree spacing (m), tree dbh (cm), and height (m) for the ten tallest trees that were within a 25.3 m radius (i.e. stand plot = 0.20 ha) from the used perch tree. For perch trees used on just two occasions, only the nearest and tallest tree to the perch tree was measured.

A Trimble Geoexplorer II® Global Positioning System (GPS) unit was used to accurately record UTM coordinates of perch sites. All perch locations were digitized into a Geographic Information System (GIS) for analysis. To determine if bald eagle perch sites were selectively used based on distance to water and wetlands, we compared used perch sites (≥ 2 events, n = 23) to randomly generated perch sites (n = 23). All random perch sites were located within the area that was effectively surveyed for a meaningful comparison. Used perch locations were compared to random locations by distance to water and distance to wetlands. If eagle locations were not significantly different with respect to these measures, then it could be said that eagles use the study area at random and therefore do not select specific perch locations relative to water and wetlands.

Associated with each perch site was the frequency of observed use. The frequency of perch use was used to determine if perch sites were used differently than would be expected based on the available area within a specific land classification: 1) the bald eagle management zone, 2) recreation zones, and 3) LTBMU lands (Neu et al. 1974, Byers et al. 1984, Alldredge and Ratti 1986). We also identified the location and frequency of use of vegetation types associated with perch sites using the US Forest Service CALVEG GIS layer.

Statistical Analysis

Mean values of measured attributes of perch trees and stand trees and differences in number of human activities between weekend and weekday observation periods were compared

using t-tests. We also employed t-tests to test for eagle-human distances between flush response types. A Hotelling's T^2 test (Stevens 1996) was used to compare distance measures of used perch sites to randomly generated perch sites. A chi-square goodness-of-fit test was used to determine whether there was a significant difference between the proportion of expected and observed use of a particular land classification (Neu et al. 1974, Byers et al. 1984). If a significant difference was detected between observed versus expected, then simultaneous confidence intervals were constructed to determine which land classification was selected greater or less than expected (Neu et al. 1974, Byers et al. 1984). Chi-squared tests were also employed to test for differences in eagle and human activity by month of year, time of week, and time of day. Tests for differences in the number of recreational activities between observations with and without eagles were conducted using t-tests for means with unequal variances. We employed one-way analysis of variance to test for differences in the number of human activities among months and time of day periods.

RESULTS

Perch Sites

All perch sites were recorded in trees. A total of 211 independent perching events were recorded at 23 perch sites where eagles were observed on at least two different observation occasions (Figure 3). Bald eagles used Jeffery or ponderosa pine (n = 9, 39%), Ponderosa pine (n = 6, 26%), Lodgepole pine (n = 3, 13%), White fir (*Abies concolor*, n = 3, 13%), and sugar pine (*Pinus lambertiana*, n = 2, 9.0%) as perch sites. Of the 211 observations, dead trees with dead tops (snags) were used most frequently (64%) for perching, while live trees with dead tops (19%) and live trees with live tops (18%) were used less, but similarly (Figure 4A). Mean perch tree height was 30.7 m (n = 23, SE ± 1.93) and the mean height of the tallest trees within the stand plot was 19.8 m (n = 167, SE ± 0.87). Mean perch tree dbh was 108.5 cm (n = 23, SE ± 6.94) and the mean dbh of the tallest trees was 53.0 cm (n = 167, SE ± 2.42). Perch trees were significantly taller ($t = 4.46$, $df = 188$, $P < 0.001$) and greater in dbh ($t = 7.92$, $df = 188$, $P < 0.001$) than the tallest trees within survey plot. Tallest trees were spaced within the survey plot on average 21.2 m (n = 167, SE ± 7.61) away from the perch tree.

Eagles used perch sites located throughout the study area with the most frequently used perch site occurring approximately 100 m west of the mouth of Taylor Creek in a snag (n = 56; Figure 3). The Jeffrey Pine vegetation type was most frequently used (82%) for perch sites while the Montane Chaparral vegetation type was used least (3%; Figure 4B). The Wetland/Wet Meadow vegetation type was the most frequently encountered (52%) vegetation type immediately adjacent to perch sites (Figure 4C). Perch sites were significantly closer to water and wetlands than randomly generated perch sites (Wilk's = 0.930, P = 0.01; Figure 4D).

Of the 211 bald eagle perching events and 23 perch sites recorded, 129 (61%) perch events and 14 (61%) perch sites occurred on National Forest System Lands (Figure 5). Eighty seven of the 129 (67%) NFS perch events and 4 of the 13 (31%) NFS perch sites were located within the NFS bald eagle management zone. Bald eagles used recreation sites (intensive dispersed, developed, and unroaded) in 102 of 129 (79%) NFS perch events and 12 of 14 (86%) NFS perch sites.

The area within the Bald Eagle Management Zone was used for perching greater than would be expected (X^2 = 312.84, df = 1, $P < 0.05$; Figure 6A) based on area available within the study area. Similarly, eagles used land managed by the LTBMU (X^2 = 7.03, df = 1, $P < 0.05$; Figure 6B) and areas designated for recreation (X^2 = 134.98, df = 1, $P < 0.05$; Figure 6C) greater than would be expected based on area available within the study area.

Foraging

We recorded 19 foraging events during the 1997-1998 season. We recorded 8 (42%) in October, 4 (21%) in November, 4 (21%) in December, 1 (5%) in January, 2 (11%) in February, and 3 (14%) in March. Nine (47%) occurred during the early time period, 8 (42%) occurred during the mid time period, and one (5%) occurred during the late period. All 19 events occurred in 5 of the 13 units (CRS, PMW, TCM, TCS, TRM; Figure 2) and 11 of the 19 (58%) events occurred at TCM. Seventeen of the 19 (90%) events occurred when no human activity was present. The remaining two events occurred with human activity at distances of 100 and 300 m.

Recreational Activities

We recorded 2,596 individual recreational activities in 1997-1998 (Figure 7A). The highest number of recreational activities in a one hour observation was 238 and occurred at TCM on 17 October, 1997. Pedestrians represented the greatest potential source of disturbance to wintering eagles and accounted for 69% of all recreational activities by frequency. Dogs, cross country skiers, other activities comprised the remaining sources of human activities (Figure 7A).

Mean counts of activities were variable and were highest during October, and lowest in November (Figure 7B). The proportion of one hour observations having ≥ 1 human activity was significantly different among months (Table 1, Figure 8A) and was greatest in October and lowest in November.

Mean counts of human activities by day of week were also variable and were highest on Sunday and lowest on Monday. The proportion of observations having ≥ 1 human activity was greatest on Thursday and lowest on Friday. The mean number of human recreational activities was significantly greater on weekends than on weekdays (Table 2, Figure 8B). The proportion of observations having ≥ 1 human activity was greater on weekends than weekdays, but not significantly different (Table 1).

The presence of ≥ 1 human activity was dependant on time of day (Table 1) and was greater during the mid (10:00 to 14:00) and late (14:00 to 18:00) time periods than the early (06:00 to 10:00) period (Figure 8C). The mean number of human recreational activities was significantly greater during the mid and late observation periods than the early observational periods (Table 2).

Human activity levels varied considerably between and among observational units (Figure 9, Table 4). We recorded the lowest human activity at PME, FLE, TC, and FLW. In contrast, we recorded the highest human activity at TRM, CRS, BBM, TCM, and BB.

Eagle Activity

Temporal patterns of eagle activity were variable. Eagle presence in units where no humans were observed was dependant on month (Table 3). Eagle presence in units where no humans were observed was greatest in December and lowest in February (Figure 8A). The

proportion of observations having eagle activity and no human presence were greater on weekends but not significantly different than on weekdays (Table 3, Figure 8B). Eagle presence in the absence of humans was independent of time of day (Table 3, Figure 8B). However, eagle use was greater during the early (06:00 to 10:00) period than the mid (10:00 to 14:00) and late (14:00 to 18:00) time periods (Figure 8C). Spatial patterns of eagle activity were also variable (Figure 9, Table 4). The percentage of one hour observations with ≥ 1 bald eagle ranged from 0% at Taylor Creek observation unit to 63% at Eagle Point observation unit.

Effects of Recreation on Eagles

The mean number of human recreational activities was not significantly different ($t = 0.21$, $df = 171$, $p = 0.197$) during one hour observational periods in which eagles were observed ($n = 119$, $\bar{x} = 8.24$, SE ± 2.244) than periods in which eagles were not observed ($n = 320$, $\bar{x} = 50.4$, SE ± 0.928). One hour observations in which ≥1 eagle were observed was just as likely ($X^2 = 0.015$, $df = 1$, $p = 0.903$) to have ≥ 1 human recreational activity (64 of 119) as observations in which no eagles were observed (170 of 320).

The distance at which humans encountered eagles affected eagles' responses. Among recorded eagle/human encounters, eagle non-flush responses ($n = 116$, $\bar{x} = 464.70$ m, SE ± 35.72) were significantly greater ($t = 9.809$, $df = 132$, $p<0.001$) than mean eagle/human encounter distances when eagle flush responses ($n = 23$, $\bar{x} = 97.20$ m, SE ± 11.30). More eagles flushed between 100 and 149 m when humans approached than in any other distance category. Eagles flushed during 23 of 139 (17%) of human encounters and all recorded flush responses occurred at distances less than 250 m (Figure 10).

DISCUSSION

Foraging

Although feeding behavior was observed, identification of prey items was difficult. However, coots, grebes and kokanee salmon were identified as prey items on some foraging events. Populations of eagles along the Toutle (Knight et al., 1991) and Nooksak Rivers (Skagen et al., 1991) in Washington must feed on salmon carcasses on the ground because salmon are too

heavy for eagles to carry. In contrast, kokanee salmon in Lake Tahoe and Taylor Creek were captured and taken to feeding perches. Knight and Knight (1984) reported that eagles perched in trees along rivers in Washington flew in response to human activity less often than eagles on the ground. Thus, because some of the prey items thought to be important to eagles in the Tahoe basin are relatively small and can be taken to tree perches by eagles, human-eagle encounters may have less of an effect on eagles than in areas where prey items are large. That most observed foraging events occurred during October and coincided with the kokanee salmon spawning period, suggests that kokanee provide a significant proportion of the eagles' nutritional needs. This observation was made by Reed (1979) who suggested that food sources other than kokanee go virtually unnoticed by eagles during October and November in the Lake Tahoe Basin. However, eagles were present in every month of our winter survey and presumably foraged on other prey items when kokanee were not available. This suggests that although kokanee salmon may be an important prey item and contribute to the nutritional requirements of eagles' during early winter months, they are not necessary to sustain a bald eagle population in the Basin throughout the winter.

The occurrence of 90% of foraging events during periods when no recreation activities were recorded suggests that eagles may prefer to forage in undisturbed areas. This is consistent with the finding of Skagen et al. (1991) who found that eagles fed more at a site on days of no disturbance than days when feeding was disrupted.

Foraging events may have been more numerous during the early hours of the day because the number of one hour observations with ≥ 1 recreational activity and the mean number of recreational activities were lower in the early time period. Foraging events were 2.3 and 7.0 times more likely to occur in the early time period than in the mid and late time periods, respectively. Other researchers (Skagen, 1980; McGarigal et al., 1991; Grubb and Kennedy, 1982; Stalmaster and Kaiser, 1998) found that normal eagle foraging activities were high in morning hours. It is unclear what constitutes "normal" behavior for bald eagles in the Tahoe Basin because no undisturbed refuges for bald eagles exist.

Effects of Recreation on Eagle Presence/Absence

The presence of at least one human recreational event or the number of recreational events in one hour observational periods did not seem to affect the probability of eagle presence during these periods. This is not surprising given our experimental design. For example, in a one hour time period eagles could have been present for the first 30 minutes and then disturbed by the presence of one or many recreational activities.

McGarigal et al. (1991) and Fraser (1981) suggested that some populations may be exposed to different levels and conditions of disturbance and therefore developed different levels of tolerance to humans. Knight and Knight (1984) reported similar results from rivers in Washington where wintering eagles were more tolerant of recreational activities where human activity was relatively high than on rivers where human activity was relatively low. These data would seem to suggest that some eagles, including residents, might habituate to extreme levels of human disturbance. On the South shore of Lake Tahoe, recreational activities occurred in large numbers (up to 238 events per one hour observation) and occurred regularly (234 of 449 one hour observations with recreational activity). Therefore, quantifiable statistical differences in eagle responses to human presence may not have been observed because non-resident eagles may have avoided the areas consistently used for recreational activities.

Flushing Distance

Only 17% of human-eagle encounters at distances of up to 1,000 m resulted in flush responses. This would suggest that human-eagle encounters might not appreciably impact the Basin's eagle population. However, cumulative eagle flush responses show that over 80% of human-eagle encounters at distances < 150 m and 100% of encounters at distances < 250 m elicited flush responses. Because, flushing increases energy expenditures due to flight, decreases energy intake by interfering with feeding, and may force eagles to leave preferred habitat (Stalmaster and Kaiser 1998) our data suggest that human-eagle encounters within these specific human-eagle encounter distances may negatively impact the Basin's eagle population. Further, once an eagle is disturbed its behavior may change for long periods of time. Skagen et al. (1991) found that after a disturbance, eagles seldom returned to feed that day. Disturbance in areas of

high human activity at major feeding grounds can cause shifts in distribution resulting in displacement of birds to lower quality habitat (Stalmaster and Newman 1978). Areas of lower quality habitat may not be available in the Tahoe Basin in the winter because habitat for prey species often freezes over or is used heavily by recreationists. Therefore, disturbance which may result in eagle displacement may result in displacement out of the Basin, or reduced winter survival.

CONCLUSIONS

In general, observation units with a high proportion of one hour observations in which an eagle was observed also had proportions of one hour observations with recreational activities. Further, eagles used land designated for recreation greater than would be expected based on area available within the study area with 79% of perching events and 86% of perching sites on National Forest System land located in designated recreation areas. Because eagles are present in areas with more recreational activity and designated recreation areas might lead to the conclusion that eagles are tolerant of human recreation. However, neither the presence of a species nor the frequency of its detection is necessarily related to the ability of the habitat to sustain individuals of a population over time (van Horne 1983). Habitat quality is defined in terms of the fitness a habitat confers on its occupants (Fretwell 1972). Knight and Knight (1984) reported wintering eagles were more tolerant of recreational activities where human activity was relatively high than on rivers where human activity was relatively low, suggesting that some eagles may habituate to extreme levels of human disturbance. Skagen et al. (1991) found that tolerance to human activity increases when bald eagles are stressed by low food availability. Disturbance to feeding bald eagles could alter social interactions by decreasing efficiency of energy acquisition (Stalmaster 1983). Therefore, use of recreational areas by bald eagles does not necessarily suggest that bald eagle populations are healthy or tolerant of recreational activities. Given the wealth of observational and experimental data which supports the conclusion that recreational activities negatively impact eagle populations, it would seem likely that eagle presence in spite of recreational activities on the South shore are a result of a preference by both eagles and

recreationists for the same available resources which comprise limited foraging opportunities for bald eagles on Lake Tahoe.

MANAGEMENT RECOMMENDATIONS

The observed use of developed recreation areas by bald eagles offers potential management strategies for land managers. Because bald eagles consistently used the same perch sites, efforts to increase the non-resident population should address protection of these perch sites. Because few individual eagles are using the South shore in the winter, efforts to re-delineate recreational areas should be made to allow habitat protection to recruit bald eagles in the future. Given that human population and recreational activities continue to grow, instituting thresholds for the quantity, timing, and/or proximity of recreational activities allowed in recreational areas used by eagles may prevent the decline of existing use of the area by bald eagles.

Although the Bald Eagle Management Zone (BEMZ) was used by perching bald eagles greater than expected within the study area, only 31% of the perching sites on National Forest System land were located in the BEMZ. This suggests that the current BEMZ should be re-evaluated to include more perching sites to supply adequate protection of eagle habitat. Further, the portions of the BEMZ that overlap the developed recreation areas should be evaluated for management priorities. As a result of year-round use of the Basin by an apparently resident eagle population, the seasonal restrictions on entry into protected areas should be re-evaluated.

In the absence of additional spatial foraging information, we must conclude that the observation units in which foraging observations occurred (CRS, PMW, TCM, TCS, and TRM) are the most important to wintering bald eagles. Areas to be considered in the re-delineation of the bald eagle management zone should include all known perch sites and foraging areas. Priority should be given to ≥ 250 m radius areas around perch sites with the highest frequency of use and foraging areas. Within the protected area(s) large (> 108.5 cm dbh), tall (> 30.7 m) trees should be protected. Trees selected should also include dead trees and live trees with dead tops. Also within these areas, recruitment trees should be retained to meet future perch site requirements. Many of these trees will meet land manager's definition for hazard trees.

Management priorities for recreational area safety and bald eagle habitat will need to be addressed.

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Table 1. Number of observational units with ≥ 1 human activity observed by month of year (MOY), time of week (TOW), and time of day (TOD) in 1997-1998 on the south shore of Lake Tahoe, CA.

	HUMAN ACTIVITY						
	Variable	Present	Not Present	n	% Present	Test Statistic	P-value
MOY	October	65	34	99	65.7		
	November	37	50	87	42.5		
	December	42	55	97	43.3		
	January	45	36	81	55.6		
	February	40	31	71	56.3		
	March	7	7	14	50.0		
		n = 236	213	449		X^2=14.39	0.013
TOW	Weekend	59	47	106	55.7		
	Weekday	177	166	343	51.6		
		n = 236	213	449		X^2=0.54	0.465
TOD	06:00-10:00	54	72	126	42.9		
	10:00-14:00	131	103	234	56.0		
	14:00-18:00	51	38	89	57.3		
		n= 236	213	449		X^2=6.66	0.036

Table 2. Number of human activities observed by month of year (MOY), time of week (TOW), and time of day (TOD), during one hour observations (Obs) in 1997-1998 on the south shore of Lake Tahoe, CA.

	Variable	No. 1 hr Obs	No. Activities	Act/Obs	Std. Error	Test Statistic	P-value
MOY	October	99	1259	12.72	3.75		
	November	87	267	3.07	0.60		
	December	97	364	3.75	0.92		
	January	81	390	4.82	0.71		
	February	71	241	3.39	0.59		
	March	14	75	5.36	3.05	F=3.63	0.003
TOW	Weekday	343	1849	5.38	0.99		
	Weekend	106	749	7.06	2.02	T=0.64	0.424
TOD	06:00-10:00	126	259	2.05	0.34		
	10:00-14:00	234	1743	7.44	1.45		
	14:00-18:00	89	594	6.67	2.30	F=3.50	0.031

Table 3. Number of observational units with ≥ 1 eagle activity and no human activity observed by month of year (MOY),time of week (TOW), and time of day (TOD), in 1997-1998 on the south shore of Lake Tahoe, CA.

		EAGLE ACTIVITY					
		Present	Not Present	n	% Present	Test Statistic	P-value
MOY	October	10	24	34	29.4		
	November	11	39	50	22.0		
	December	20	35	55	36.4		
	January	15	21	36	41.7		
	February	3	28	31	9.7		
	March	1	6	7	14.3		
	n =	60	153	213		X^2=11.94	0.036
TOW	Weekend	17	30	47	36.2		
	Weekday	43	123	166	25.9		
	n =	60	153	213		X^2=1.91	0.167
TOD	06:00-10:00	22	50	72	30.6		
	10:00-14:00	26	77	103	25.2		
	14:00-18:00	12	26	38	31.6		
	n =	60	153	213		X^2=0.86	0.652

Table 4. Number and percentage of one hour observations (Obs.) with A) ≥ 1 bald eagle and B) ≥ 1 human by observational unit on the South shore of Lake Tahoe, 1997-1998.

A)

Observation Unit	No. Obs.	No. Obs. with no eagles	% Obs. with eagles
TC	17	17	0.0
FLN	14	13	7.1
FLE	20	18	10.0
PME	41	35	14.6
TRM	11	9	18.2
FLW	16	13	18.8
PMW	23	16	30.4
CRS	11	6	45.5
BBM	17	8	52.9
TCM	18	8	55.6
PBS	7	3	57.1
BB	5	2	60.0
TCS	5	2	60.0
EP	8	3	62.5

B)

Observation Unit	No. Obs.	No. Obs. with no humans	% Obs. with humans
EP	10	8	20.0
PME	54	41	24.1
TC	23	17	26.1
FLE	28	20	28.6
FLW	24	16	33.3
PMW	47	23	51.1
FLN	29	14	51.7
PBS	17	7	58.8
TCS	13	5	61.5
BBM	45	17	62.2
TCM	51	18	64.7
CRS	34	11	67.6
BB	20	5	75.0
TRM	54	11	79.6

FLE=Fallen Leaf East
PME=Pope Marsh East
TCS=Taylor Creek Shoreline
CRS=Camp Rich Shoreline
PBS=Pope Beach Shoreline
TC=Taylor Creek
FLW=Fallen Leaf West
TRM=Trout Marsh
TCM=Taylor Creek Marsh
EP=Eagle Point
FLN=Fallen Leaf North
PMW=Pope Marsh West
BBM=Baldwin Beach Marsh
BB=Baldwin Beach Shoreline